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HYDRAULIC POWER TRANSFER SYSTEMS. AGRICULTURAL MACHINERY--SERVICE OCCUPATIONS, MODULE NUMBER 9.

OHIO STATE UNIV., COLUMBUS, CENTER FOR VOC. EDUC.
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ONE OF A SERIES DESIGNED TO HELP TEACHERS PREPARE POSTSECONDARY-LEVEL STUDENTS FOR THE AGRICULTURAL MACHINERY SERVICE OCCUPATIONS AS PARTS MEN, MECHANICS, MECHANIC'S HELPERS, AND SERVICE SUPERVISORS, THIS GUIDE AIMS TO DEVELOP STUDENT COMPETENCY IN UNDERSTANDING BASIC HYDRAULICS AND ITS APPLICATION TO AGRICULTURAL MACHINERY. IT WAS DEVELOPED BY A NATIONAL TASK FORCE ON THE BASIS OF RESEARCH FROM STATE STUDIES. SUGGESTIONS FOR INTRODUCING THE MODULE ARE GIVEN. UNITS ARE--(1) TERMINOLOGY, (2) OPERATIONAL PRINCIPLES, (3), SYSTEMS, (4) PUMPS, (5) VALVES, (6) CYLINDERS, (7) PACKINGS, SEALS, LINES, AND FITTINGS, (8) SYSTEM TYPES AND TROUBLES, (9) OILS, AND (10) TROUBLESHOOTING PROCEDURES. EACH UNIT INCLUDES SUGGESTED SUBJECT-MATTER CONTENT, TEACHING-LEARNING ACTIVITIES, INSTRUCTIONAL MATERIALS, AND REFERENCES. SUGGESTIONS ARE MADE FOR EVALUATING EDUCATIONAL OUTCOMES. THE SUGGESTED TIME ALLOTMENT IS 90 HOURS OF CLASS INSTRUCTION, 120 HOURS OF LABORATORY EXPERIENCE, AND 60 HOURS OF OCCUPATIONAL EXPERIENCE. TEACHERS SHOULD HAVE EXPERIENCE WITH AGRICULTURAL MACHINERY. STUDENTS SHOULD HAVE MECHANICAL APTITUDE AND AN OCCUPATIONAL GOAL IN AGRICULTURAL MACHINERY. THIS DOCUMENT IS ALSO AVAILABLE FOR A LIMITED PERIOD AS PART OF A SET (VT 000 488 THROUGH VT 000 504) FROM THE CENTER FOR VOCATIONAL AND TECHNICAL EDUCATION, THE OHIO STATE UNIVERSITY, 980 KINNEAR ROAD, COLUMBUS, OHIO 43212, FOR $7.50 PER SET. (JM)

# HYDRAULIC POWER TRANSFER SYSTEMS

One of Sixteen Modules in the Course Preparing for Entry in

**AGRICULTURAL MACHINERY - SERVICE OCCUPATIONS**

Module No. 9

The Center for Research and Leadership Development

in Vocational and Technical Education

The Ohio State University
980 Kinnear Road
Columbus, Ohio, 43212

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United States Office of Education

August, 1965

# M E M O R A N D U M

TO: The ERIC Clearinghouse on Vocational and Technical Education
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FROM: (Person) James W. Hensel (Agency) The Center for Vocational and Technical Education

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DATE: August 4, 1967

RE: (Author, Title, Publisher, Date) Module No. 9, "Hydraulic Power Transfer Systems," The Center for Vocational and Technical Education, August, 1965.

## Supplementary Information on Instructional Material

Provide information below which is not included in the publication. Mark N/A in each blank for which information is not available or not applicable. Mark P when information is included in the publication. See reverse side for further instructions.

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(3) Utilization of Material:
Appropriate School Setting Post high school
Type of Program General post high school class in agricultural machinery
Occupational Focus Agricultural machinery service occupations
Geographic Adaptability Nationwide
Uses of Material Instructor course planning
Users of Material Teachers

(4) Requirements for Using Material:
Teacher Competency Background in agricultural machinery
Student Selection Criteria Post high school, mechanical aptitude, high school background, goal in agricultural machinery service occupation.
Time Allotment Estimated time listed in module. (P)

Supplemental Media --
Necessary x
Desirable
(Check Which)

Describe Suggested references given in module. (P)

Source (agency)
(address)

# HYDRAULIC POWER TRANSFER SYSTEMS

# HYDRAULIC POWER TRANSFER SYSTEMS

## Major Teaching Objective

To understand basic hydraulics and its application to agricultural machinery

## Suggested Time Allotments

| | | |
|---|---|---|
| At school | | |
| Class instruction | 90 hours | |
| Laboratory experience | 120 hours | |
| Total at school | | 210 hours |
| Occupational experience | | 60 hours |
| Total for module | | 270 hours |

## Suggestions for Introducing the Module

The application of hydraulic principles to agricultural machinery operation has become increasingly more important in recent years. The size, weight, and complexity of modern agricultural machinery requires a much more powerful and flexible means of control. These machines are required to perform more jobs requiring more power to conduct them. Hydraulic principles have provided agricultural machinery designers with a practical means of meeting new demands placed on agricultural machinery.

Modern hydraulic systems on many types of agricultural machines seem complicated, and some are. Actually, the fundamental design is quite simple.

A person planning to work as an agricultural machinery mechanic must thoroughly understand basic hydraulic principles and systems and their application to agricultural machinery. He must also be able to recognize types of hydraulic pumps and valves and their parts and functions (cylinders, seals and packings, and lines and fittings) if he is to repair and service hydraulic systems on agricultural machinery properly.

The study of hydraulic transmissions has been omitted from this module. Due to the degree of specialization in this field, industry representatives felt that training is this area could best be provided through their service schools.

The following are suggested techniques for use in creating interest in the module:

1. Place various hydraulic system parts around the classroom and have the students attempt to identify them. Emphasize the need for being able to identify parts of the hydraulic system in order to work effectively on hydraulic systems.

2. Bring several agricultural machines before the class that have faulty hydraulic systems. Have students attempt to locate the source of the problem in each system.

3. Demonstrate before the class how a small piston can increase the output force of a hydraulic system. Have students attempt to explain how this phenomenon takes place.

## Competencies to be Developed

I. To understand hydraulic terminology

### Teacher Preparation

#### Subject Matter Content

The following terms should be thoroughly understood as they relate to hydraulic systems:

1. Actual size
2. Aeration
3. Ambient temperature
4. Atmospheric pressure
5. Back pressure
6. Baffle
7. Bernoullis principles
8. Bleed-off
9. Breather
10. By-pass of filter
11. By-pass
12. Cavitation
13. Chamber
14. Check valve
15. Circuit
16. Components
17. Control valves
18. Cylinders
19. Displaced oil
20. Feather
21. Filter
22. Flexible hose
23. Float
24. Fluids
25. Force
26. Four-way valve
27. Four-way four position spool
28. Four-way three position spool
29. Friction
30. Full-flow filter
31. G.P.M.
32. High pressure
33. Horsepower
34. Hydraulics
35. Inertia
36. Knock out valve
37. Line
38. Liquid
39. Low circulating pressure
40. Minimal size
41. Motion
42. Neutral
43. Non-position displacement pump
44. Operator
45. Pascal's law
46. Pipe
47. Positive displacement
48. Power point
49. Power
50. Pressure
51. Pressurized
52. Proportional type filter
53. PSI
54. Pump
55. Quantity of flow
56. Rate of flow
57. Relief valve
58. Reservoir
59. Resistance

60. R.P.M.
61. Sealed system
62. Spool
63. Static pressure
64. Strainer
65. Surge
66. Tubing
67. Two-way valves
68. Vacuum
69. Valve
70. Velocity
71. Vent
72. Viscosity index
73. Work
74. Energy
75. Pressure drop
76. Compressibility
77. Oscillation

Suggested Teaching-Learning Activities

Success in teaching this competency will depend on the teacher's ability to create interest in understanding these terms. Demonstration of the meaning of the terms, when possible, will provide the stimulus for this interest.

The majority of these terms can be demonstrated by using the hydraulic demonstration unit referred to in the suggested instructional materials.

Suggested Instructional Materials and References

Instructional materials

1. Hydraulic demonstration unit

2. Pumps, lines valves, etc., to demonstrate terms

References

S*1. Hydraulic Theory, Section I

*The symbol T (teacher) or S (student) denotes those references designed especially for the teacher or for the student.

## II. To understand principles of hydraulic operation

### Teacher Preparation

Subject Matter Content

The word hydraulics is a term applied to a science that deals with the physical behavior of liquids. Included in these liquids

are oils used in present day hydraulic systems. The study of hydraulics include

1. The laws of floating bodies
2. The flow of liquids under various conditions
3. Ways of directing the flow of liquids to useful ends

In order to understand the physical behavior of liquids, the physical properties of liquids must be thoroughly understood. These include

1. Shapelessness
2. Incompressibility
3. Density
4. Specific gravity

Liquids have no outer form of their own. They quickly conform in shape to their containers. They can be led almost anywhere in a pipe or a base by means of gravity or by applying force to them.

Even though liquids have no shape of their own, they are even less compressible than most solids. When a force is applied to a confined liquid, it exhibits substantially the same effect of rigidity as a solid. This rigidity can be combined with fluidity to transmit a force.

> Example--A force of 15 pounds on a cubic inch of a particular fluid will decrease its volume by only 1/20,000. It would take a force of over 32 tons to reduce it 10 per cent.

Pressure set up in a liquid acts equally in all directions. The shape of the container in no way alters pressure relations.

> Example--See figure 10. p. 10.

Pressure due to the weight of a liquid depends upon the vertical height of liquid from a given level to the surface of the liquid. The vertical distance between two horizontal levels in a liquid is known as the head of the liquid. (Refer to Basic Hydraulics, p. 9.)

Density refers to weight of fluid per unit of volume.

Example--Water weighs 62.4 pounds per cubic foot. A certain oil might weigh 55 pounds per cubic foot.

Specific gravity of a substance is the ratio of the weight of a unit volume of that substance, its density, to the weight of the same volume of some standard substance, measured under standard pressure and temperature conditions.

1. Water is the standard used for liquids and solids.

2. The weight of water is 62.4 pounds per cubic foot.

3. The weight of a given oil might be 55 pounds per cubic foot.

4. The specific gravity of the oil is computed in the following manner: 55/62.4 = .88 specific gravity.

By confining the fluid and adding pressure, the above principles can be applied to agricultural machinery.

Pressure is defined as force divided by the area over which it is distributed.

Example--See Basic Hydraulics, figures 10 - 12, pp. 10-12.

When two pistons are used in a hydraulic system, two basic rules always apply.

1. The force acting on each piston is directly proportional to its area, and the magnitude of each force is the product of the pressure and its area.

2. The distance the receiving piston is moved is inversely proportional to the area of the exerting piston.

Example--See Basic Hydraulics, figure 12, p. 12.

To understand the work output of a hydraulic system, an agricultural mechanic must understand input and output relations of a hydraulic system.

1. An increase in output force over input force is accompanied in exactly the same ratio by a decrease in the distance moved.

2. An increase in force can be obtained only by a proportional decrease in the distance the fluid is moved.

3. A distance increase can be obtained only at the expense of a force decrease in the same ratio.

4. In any hydraulic system, the input force multiplied by the distance through which it moves is always exactly equal to the output force multiplied by the distance through which it moves.

5. The total output in all forms always exactly equals the total energy input.

6. All of the above factors are subject to frictional loses.

When studying the working relations of a hydraulic system, one must understand the terms work and energy as they relate to hydraulic systems.

1. The amount of work done is the product of the force multiplied by the distance through which it moves.

2. Energy includes work and all the forms into which work can be converted or forms which can be converted into work.

In all working parts of hydraulic systems friction is present as the parts operate.

1. Work done against friction in a hydraulic system produces heat.

2. Heat produced in the hydraulic system is a form of energy dissipation causing a change in the input-output relationship.

In order to understand hydraulic systems in agricultural machinery in action, one must become acquainted with the characteristics of liquids in motion. Among these characteristics are

1. Volume and velocity of flow

2. Steady and unsteady flow

3. Streamline and turbulent flow

4. Force and energy changes

5. Relations of different kinds of energy to each other

Volume of flow refers to the amount of fluid that passes a given point in a hydraulic system in a given length of time. The rate of speed at which the fluid is moving forward at a particular point in the hydraulic system is called velocity of flow. It is expressed in such terms as 100 cubic feet per minute, or 100 gallons per minute or hour (G.P.M.).

A single continuous stream of fluid is known as a steady flow. When this continuous stream is interrupted by increasing or decreasing the volume of fluid passing a given point in the system, unsteady flow develops. The unsteadiness of flow is temporary, however, since it occurs during the time the rate of flow is increasing or decreasing to the new rate of flow. After it reaches this new level, a steady flow is re-established.

Streamline flow of hydraulic fluids refers to the action of fluid particles as they move straight forward without crossing the paths of other particles and without bumping into other particles. Streamline flow is accomplished under the following conditions:

1. When the fluid is flowing at low velocities

2. When the fluid is flowing through tubes or lines with small diameters

Turbulent flow of hydraulic fluid occurs when colliding fluid particles cause swirls, eddies, and cross-motions to develop in a hydraulic line. Turbulence in a hydraulic system is caused by the following:

1. Increases in the velocity of the fluids

2. Narrowing of the fluid passageway

3. Roughness of the inside of the hydraulic line

4. Dirt in the fluid

5. Degree of curvature of bends in the line

6. Friction in the hydraulic line

Five physical factors act upon the fluid in a hydraulic system.

1. Gravity
2. Atmospheric pressure
3. Specified applied forces
4. Friction
5. Inertia

   Inertia is that property possessed by all forms of matter which makes the matter resist being moved if it is at rest and, likewise, resist any change of motion if it is moving.

   a. To overcome this resistance to movement, some force must act on the object.

   b. A direct relationship develops between the magnitude of the force exerted and the inertia against which it acts. This force depends on two factors.

      1) The mass of the subject to be moved
      2) The rate at which the velocity of the object is changed

All of the physical actions of liquids in all agricultural machinery systems are determined by the relationships of these five factors to each other.

Suggested Teaching-Learning Activities

1. Through the use of the hydraulic demonstration unit, demonstrate shapelessness and incompressibility of hydraulic fluids.

2. Have students measure the amount of pressure exerted on a piston using the following hydraulic cylinders:

   a. A cylinder with an exerting piston of the same size

   b. A cylinder with a smaller initiating piston

   c. A cylinder with multiple pistons of different sizes

3. Have students work the following problems:

a. How much pressure is exerted on piston "b" in illustration No. 1?

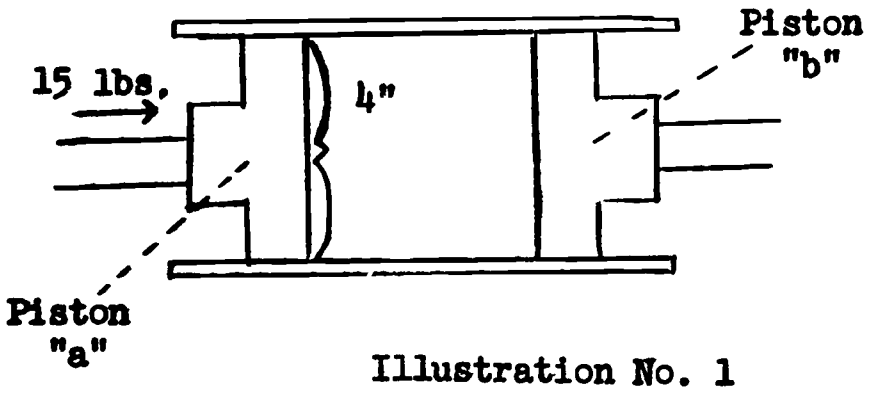


Illustration No. 1

b. Piston "a" in Illustration No. 2, is the initiating piston and has an area of 3 square inches. Sixty pounds of pressure is applied to piston "a."

1) How much pressure is exerted on piston "b," whose area is 9 square inches?
2) How much pressure is exerted on piston "c," whose area is 7 square inches?
3) How much pressure is exerted on piston "d," whose area is 4 square inches?

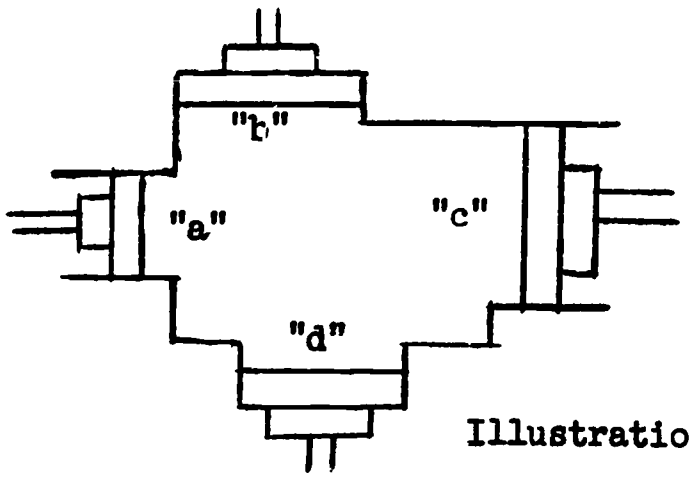


Illustration No. 2

c. If the initiating piston has an area of 3 square inches in Illustration No. 3, how much pressure is exerted on piston "b," whose area is 12 square inches.

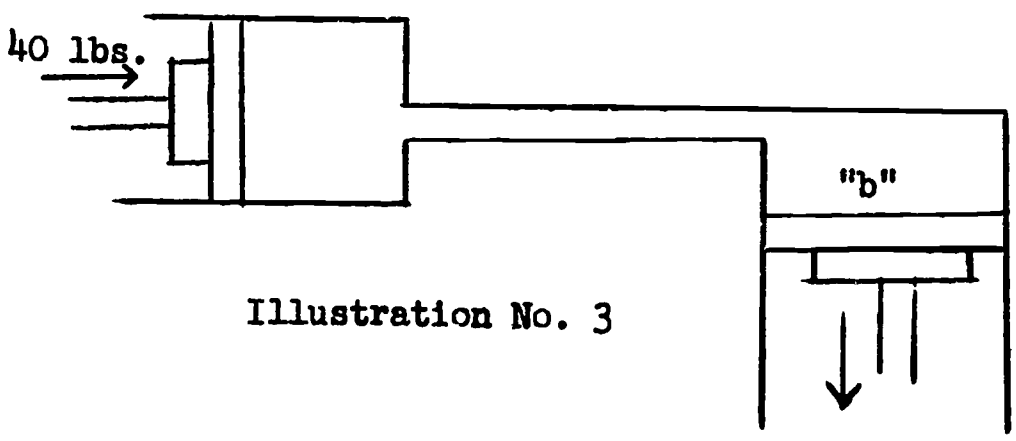


Illustration No. 3

d. What is the pressure exerted on the bottom of a container by a column of liquid 200 inches high, if it's cross-section area is 60 square inches and it weighs .06 pounds per cubic inch?

e. What is the weight of a column of oil 40 inches high if it's cross-section area is 20 square inches and weighs .06 pounds per cubic unit?

f. A hydraulic jack has a single output piston with an area of 50 square inches. The area of the input is 10 square inches. If a force of 10 pounds is exerted on the input piston, how much force will be exerted on the output piston?

g. If the input in problem "f" is moved downward 5 inches, how far will the output piston be moved?

Suggested Instructional Materials and References

Instructional materials

1. A simple hydraulic pump for disassembly

2. Three different types of pumps for use in determining the amount of pressure exerted on the receiving piston

References

S 1. Hydraulics, pp. 3-6

S 2. Basic Hydraulics, pp. 1-45

III. To understand the basic hydraulic system

Teacher Preparation

Subject Matter Content

Hydraulics, pp. 6-10

Hydraulic Theory, pp. 28-34

Hydraulics should be used as a basic reference and the materials followed in the order they are presented in the reference. The materials in Hydraulic Theory should be used to supplement Hydraulics.

Suggested Teaching-Learning Activities

1. Using charts, graphs, and mockups, show the components of the basic hydraulic system and its operation.

2. Have students disassemble a simple hydraulic system to identify the parts and their functions.

3. Using a plastic model of a simple hydraulic system, demonstrate to the class how the system operates. As the system is demonstrated, restrict the output of the pump to cause the relief valve to operate.

Suggested Instructional Materials and References

Instructional materials

1. A simple hydraulic pump for each student

2. A plastic model of a simple hydraulic system

References

1. Hydraulics, pp. 6-10

2. Hydraulic Theory, pp. 28-34

IV. To (1) identify various types of hydraulic pumps and (2) understand how they operate

Teacher Preparation

Subject Matter Content

Hydraulics, pp. 10-17

Hydraulic Theory, pp. 37-46

Hydraulic Fundamentals, pp. 10-13

Basic Hydraulics, pp. 186-270

Hydraulics should be followed as the basic reference and the materials covered in the order they are presented. The other three references listed above should be used to supplement Hydraulics.

## Suggested Teaching-Learning Activities

1. Using charts, models, and mockups, discuss and identify the parts and functions of each of the kinds of hydraulic pumps.

2. Have students disassemble each kind of pump, identify its parts and reassemble it.

3. Using machinery brought to the school shop or available at local agricultural machinery dealerships, show the class examples of machines on which each type of hydraulic pump is used.

4. Demonstrate the use of high pressure guage to check maximum pressure from the setup.

5. Using a flowmeter, check the output of the pump.

6. Adjust pressure relief valve to show the various pressures obtainable from a setup.

7. Demonstrate how a plugged filter or screen on the intake of the pump will diminish the volume output of the pump.

## Suggested Instructional Materials and References

Instructional materials

1. Charts, models and mockups of the different kinds of hydraulic pumps discussed in the content

2. Hydraulic pumps of each type discussed in the content

References

1. Hydraulics, pp. 10-17

2. Hydraulic Theory, pp. 37-46

S 3. Hydraulic Fundamentals, pp. 10-13

4. Basic Hydraulics, pp. 186-270

Suggested Occupational Experience

Have students repair several hydraulic pumps in the service department of a local farm machinery dealership.

V. To (1) identify various types of valves used in hydraulic systems and (2) understand their functions

## Teacher Preparation

Subject Matter Content

Hydraulic Machinery, pp. 25-32

Hydraulics, pp. 17-24

Hydraulic Fundamentals, pp. 14-16

Basic Hydraulics, pp. 92-152

Hydraulic Machinery and Hydraulics should be followed as the basic references for teaching this competency and the materials covered in the order they are presented. The other two references should be used to supplement Hydraulic Machinery and Hydraulics.

Suggested Teaching-Learning Activities

1. Have students disassemble and identify the parts of each of the valves identified in the content.

2. Have students hook up each type of valve to a hydraulic line and observe how it functions.

3. After the class has completed the above activities, place various valves and valve parts around the classroom and have the students identify them.

4. Show the class examples of worn valves, pointing out the causes for their wear.

Suggested Instructional Materials

Instructional materials

Valves of each kind identified in the content

References

1. Hydraulic Machinery, pp. 25-32
2. Hydraulics, pp. 17-24
3. Hydraulic Fundamentals, pp. 14-16
4. Basic Hydraulics, pp. 92-152

Suggested Occupational Experience

Have students locate valves that are working improperly on hydraulic systems.

Have students replace worn-out valves on hydraulic systems.

VI. To (1) understand hydraulic cylinders and (2) develop the ability to maintain them

Teacher Preparation

Subject Matter Content

Hydraulic Machinery, pp. 20-24

Hydraulics, pp. 24-28

Hydraulic Theory, pp. 55-56

Hydraulics should be followed as the basic reference and the materials covered in the order they are presented. The other two references should be used to supplement Hydraulics.

Suggested Teaching-Learning Activities

1. Using charts and models, demonstrate to the class how a cylinders works and how cylinders differ.
2. Demonstrate with actual models the differences between the types of cylinders identified in the content.
3. Bring several hydraulic cylinders to class that are malfunctioning in different ways. Have students locate

the trouble causing the malfunctioning and correct it. (Possible causes of cylinder malfunctioning are given on pp. 22-23 of Hydraulic Machinery.)

4. Use a power steering pump on a tractor to demonstrate pump, cylinders, etc.

Suggested Instructional Materials and References

Instructional materials

1. Charts and models of the different types of hydraulic cylinders

2. Hydraulic cylinders that are not operating properly

References

1. Hydraulic Machinery, pp. 34-43

2. Hydraulics, pp. 24-28

3. Hydraulic Theory, pp.55-56

Suggested Occupational Experiences

1. Have students test hydraulic cylinders for leaks, and other malfunctions.

2. Have students correct malfunctions in hydraulic systems brought to a local agricultural machinery dealership for repair.

VII. To (1) recognize various types of packings, seals, lines, and fittings, and (2) understand how they are used on agricultural machinery and hydraulic systems

Teacher Preparation

Subject Matter Content

Hydraulics, pp. 28-31

Hydraulic Machinery, pp. 34-43

Basic Hydraulics, pp. 67-90

Hydraulics should be followed as the basic reference and the materials covered in the order they are presented in the reference. The other two references should be used to supplement Hydraulics.

Suggested Teaching-Learning Activities

1. Have students identify various types of tubing, packings, and seals used in several agricultural machinery hydraulic systems.

2. Have students replace worn-out tubing, packings, and fittings on hydraulic systems on agricultural machines.

Suggested Instructional Materials and References

Instructional materials

1. Various samples of different types of tubing, packings, and seals used on agricultural machinery hydraulic systems

2. Agricultural machinery hydraulic systems with worn tubings, packings, and seals

3. New hydraulic tubings, packings, and seals

References

1. Hydraulics, pp. 28-31

2. Hydraulic Machinery, pp. 34-43

3. Basic Hydraulics, pp. 67-90

VIII. To understand types of hydraulic systems used on agricultural machinery

Teacher Preparation

Subject Matter Content

Hydraulics, pp. 35-38

Hydraulic Theory, pp. 57-65

Hydraulics should be followed as the basic reference and the materials covered in the order they are presented. The materials in Hydraulic Theory should be used to supplement those in Hydraulics.

Suggested Teaching-Learning Activities

1. Have available for the class a tractor with a hydraulically-controlled implement attached. Disassemble the hydraulic system, identifying each part and explaining its function to the class.

2. Have students disassemble several types of hydraulic systems studied in the content. Have them identify each part of the system and reassemble it.

3. Have students visit a local agricultural machinery dealership and identify the types of hydraulic systems used on the agricultural machinery at the dealership.

Suggested Instructional Materials and References

Instructional materials

1. A tractor with a hydraulically-operated implement attached

2. Charts and diagrams of hydraulic systems

3. Several hydraulic systems covered in the content

References

1. Hydraulics, pp. 35-38

2. Hydraulic Theory, pp. 57-65

3. Machines for Power Farming, pp. 109-115

## IX. To understand hydraulic system troubles

### Teacher Preparation

Subject Matter Content

Hydraulics, pp. 33-35

Suggested Teaching-Learning Activities

1. Bring to the class a ruptured line, an exploded cylinder, and a collapsed suction hose. Explain to the class the causes of these defects. Point out the different amounts of pressures created by various makes of tractors and their relationships to these problems.

2. Bring to the class several agricultural machines whose hydraulic systems are not operating properly. Have the students determine what is wrong in each system and correct it.

3. Demonstrate to the class what happens to a hydraulic line when the wrong size of pump is used in a hydraulic system.

4. Demonstrate what can happen when cotton braid base is used instead of wire braid base under high pressure.

Suggested Instructional Materials and References

Instructional materials

1. A ruptured hydraulic line, an exploded cylinder, and a collapsed suction hose

2. Several agricultural machines with hydraulic systems that are not working properly

3. A hydraulic system and several hydraulic pumps of different sizes

References

Hydraulics, pp. 33-35

X. To understand the types and qualities of hydraulic oils

Teacher Preparation

Subject Matter Content

Hydraulics, pp. 41-43

Hydraulic Theory, pp. 24-28

Hydraulic Fundamentals, pp.23-34

Hydraulic Machinery, pp. 49-69

Hydraulics should be followed as the basic reference and the materials covered in the order they are presented. The other three references should be used to supplement Hydraulics.

## Suggested Teaching-Learning Activities

Demonstrate the following before the class:

1. Pour point
2. Effects of foaming
3. Sludge deposits
4. Aniline point
5. Viscosity
6. Oxidation of hydraulic oil

## Suggested Instructional Materials and References

Instructional materials

1. Saybolt meter
2. Test tubes for demonstrating pour point
3. A hydraulic system with oil that foams badly and has a build-up of sludge
4. Test tubes, hydraulic oils, aniline dyes, and gas burner

References

1. Hydraulics, pp. 41-43
2. Hydraulic Theory, pp. 24-23
3. Hydraulic Fundamentals, pp. 23-34
4. Hydraulic Machinery, pp. 49-69

XI. To (1) understand hydraulic system trouble shooting procedures and (2) be able to locate failures in hydraulic systems

## Teacher Preparation

### Subject Matter Content

Operation and Care of Hydraulic Machinery, pp. 84-91

Hydraulic Fundamentals, pp. 38-40

Hydraulic Fundamentals should be followed as the basic reference in teaching this competency. The materials should be covered in the order they are presented.

### Suggested Teaching-Learning Activities

Using the trouble shooting chart in Hydraulic Fundamentals, pp. 39-42, have students trouble shoot several faulty hydraulic systems on agricultural machines.

### Suggested Instructional Materials and References

Instructional materials

Several faulty hydraulic systems

References

1. Hydraulic Fundamentals, pp. 38-40

S 2. Operation and Care of Hydraulic Machinery, pp. 84-91

### Suggested Occupational Experience

Have students trouble shoot several hydraulic systems at local agricultural machinery dealerships.

## Suggestions for Evaluating Educational Outcomes of the Module

The educational outcome of the module should be evaluated according to the following criteria:

1. Changes in student understanding of hydraulic principles as they relate to agricultural machinery

2. Ability of the student to diagnose hydraulic system problems and correct them (Each student should be required to trouble shoot a hydraulic system and correct any problems encountered.)

3. Student interest in the materials covered in this module

4. Changes in attitude on the part of the student toward his work

5. Changes in student understanding of agricultural machinery hydraulics, as determined by the difference in scores in pre- and post-tests in hydraulics.

## Sources of Suggested Instructional Materials and References

### Instructional Materials

E. M. Hydraulic Trainer, Electromatic. Box 182, Mc Minnville, Tennessee.

### References

1. Basic Hydraulics, NAVPERS 16193. Washington 25, D.C.: U. S. Government Printing Office.

2. Hydraulic Fundamentals, Philadelphia: Sun Oil Co., 1608 Walnut Street.

3. Hydraulic Machinery, New York 17: Texaco, Inc., 135 East 42nd Street.

4. Hydraulics, Bulletin No. GSS 1277-Z. Chicago: International Harvester Co., 180 N. Michigan Avenue. Price: $1.50 per copy.

5. Hydraulic Theory, Racine, Wisconsin: J. I. Case Company.

6. Operation and Care of Hydraulic Machinery, Texaco Inc., 135 East 42nd Street, New York 17, New York, 1962.

7. Stone and Gulvin. Machines for Power Farming, New York: John Wiley and Sons, Inc. Price: $5.95.

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THE OHIO STATE UNIVERSITY
980 KINNEAR ROAD
COLUMBUS, OHIO, 43212

INSTRUCTOR NOTE: As soon as you have completed teaching each module, please record your reaction on this form and return to the above address.

1. Instructor's Name_____

2. Name of school_____State_____

3. Course outline used: _____Agriculture Supply--Sales and Service Occupations
   _____Ornamental Horticulture--Service Occupations
   _____Agricultural Machinery--Service Occupations

4. Name of module evaluated in this report_____

5. To what group (age and/or class description) was this material presented?____
   _____

6. How many students:
   a) Were enrolled in class (total) _____
   b) Participated in studying this module _____
   c) Participated in a related occupational work experience program while you taught this module _____

7. Actual time spent teaching module:

| | | Recommended time if you were to teach the module again: |
|---|---|---|
| _____hours | Classroom Instruction | _____hours |
| _____hours | Laboratory Experience | _____hours |
| _____hours | Occupational Experience (Average time for each student participating) | _____hours |
| _____hours | Total time | _____hours |

(RESPOND TO THE FOLLOWING STATEMENTS WITH A CHECK (✓) ALONG THE LINE TO INDICATE YOUR BEST ESTIMATE.)

| | VERY APPROPRIATE | NOT APPROPRIATE |
|---|---|---|
| 8. The suggested time allotments given with this module were: | | |
| 9. The suggestions for introducing this module were: | | |
| 10. The suggested competencies to be developed were: | | |
| 11. For your particular class situation, the level of subject matter content was: | | |
| 12. The Suggested Teaching-Learning Activities were: | | |
| 13. The Suggested Instructional Materials and References were: | | |
| 14. The Suggested Occupational Experiences were: | | |

(OVER)

15. Was the subject matter content sufficiently detailed to enable you to develop the desired degree of competency in the student? Yes_____No_____
Comments:

16. Was the subject matter content directly related to the type of occupational experience the student received? Yes_____No_____
Comments:

17. List any subject matter items which should be added or deleted:

18. List any additional instructional materials and references which you used or think appropriate:

19. List any additional Teaching-Learning Activities which you feel were particularly successful:

20. List any additional Occupational Work Experiences you used or feel appropriate:

21. What do you see as the major strength of this module?

22. What do you see as the major weakness of this module?

23. Other comments concerning this module:

(Date) (Instructor's Signature)

(School Address)